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ABSTRACT

A computer-assisted simulation of the "chart method" of teaching has been developed and was used to provide instruction in clinical decision-making in the diagnosis and treatment of pulmonary diseases. The course requires a student to reach and defend a diagnosis and to provide appropriate treatment for each of 10 simulated cases. Evaluation of performance and immediate feedback and correction of errors of commission and omission are an integral part of the course. The course provides a model for development of additional programs in other subject areas. (Author)

A Computer-Assisted Instruction Course in the Diagnosis and Treatment of Respiratory Diseases[1-3]

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SUMMARY

A computer-assisted simulation of the "chart method" of teaching has been developed and was used to provide instruction in clinical decision-making in the diagnosis and treatment of pulmonary diseases. The course requires a student to reach and to defend a diagnosis and to provide appropriate treatment for each of 10 simulated cases. Evaluation of performance and immediate feedback and correction of errors of commission and omission are an integral part of the course. The course provides a model for development of additional programs in other subject areas.

Introduction

Continuing education of all physicians is a major goal of the medical profession. As a physician becomes more and more involved in the practice of medicine, he or she has little time for study. After completing his training, the physician no longer practices in a supervised environment. His judgments are then rarely challenged and his errors often go undetected. The effectiveness of his performance is therefore difficult to ascertain.

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1 From the State University of New York Downstate Medical Center, 450 Clarkson Ave., Brooklyn, and the Graduate School of the City University of New York.

2 Supported in part by a grant from the American Lung Association.

3 The language used is IBM's Coursewriter III and is a time sharing system. Any terminal compatible with a coursewriter system can be used (e.g., ASCII or EBCDIC). Terminals typically range from $50 to $200 per month for rental and from $1,500 to $5,000 for purchase. In addition to terminal costs, other expenses are for computer time, approximately $5 to $10 per connect-hour, and for telephone charges from terminal to computer. Detailed information can be obtained from Charles M. Plotz, M.D., Downstate Medical Center, Box 51, 450 Clarkson Ave., Brooklyn, N.Y. 11203.

To further their education and, hopefully, to sharpen their diagnostic acumen, many physicians attend continuing education courses. The basic format of these courses is didactic and is not tailored to the specific needs of the individual doctor. They frequently fail to instruct him in correct clinical decision-making. They require time, and time is a precious commodity to the practicing physician. Certainly, most physicians want to improve their knowledge, but it is difficult to stereotype this requirement into a specific weekly or monthly time period. The level of instruction in each course is variable, and a physician might be confronted, on one hand, with a course that is "above his head," or on the other, with one of content already well within his knowledge.

Computer-assisted instruction (CAI) was introduced into the teaching of pulmonary diseases to overcome these problems of conventional continuing medical education courses. This method attempts to instruct the physician-student in clinical decision-making through simulated "chart teaching." The student can use the instructional material at his convenience, for 1 hour, or 10 hours, depending on his desire. Material well known to the student can be handled in short order, whereas other, more difficult items require more time. Furthermore, his answers are evaluated immediately, and cor-

rection of errors of commission and omission are an integral part of the course.

Materials and Methods

Course design. The course content was provided by 2 physicians expert in pulmonary diseases who did not require instruction in computer use or technology. The course content was evaluated, when necessary, by other pulmonary physicians. An educational psychologist helped design the pedagogic approach as well as systems for evaluation. A programmer provided the necessary information concerning the technical aspects of preparing the cases in a format that was adaptable to programming in Coursewriter III.

The course consists of 10 simulated "patients" with pulmonary disease. The programming model was the same for each patient, thus permitting development of a model suitable for preparing additional courses in other subject areas. The "patients" with pulmonary disease were presented to simulate "chart teaching."

Chart teaching. The chart method of teaching in medicine is an instructional technique wherein the student receives immediate feedback concerning his performance. This method allows a single instructor to teach small groups of students at the bedside. The instructor asks the student to make a diagnosis and then elicits a defense of that diagnosis. The student is also expected to institute proper management. The instructor questions the student about the bases of his decisions and tries to clarify any issues in doubt.

Chart teaching, in an ideal sense, requires the student to make and defend diagnoses, and to suggest management for patients who have a wide variety of diseases. The student must be supervised and must receive immediate correction of his errors to prevent him from developing poor diagnostic habits. He is provided with an evaluation of his performance at the end of each session so that he can remedy his deficiencies. This method of instruction can continue until the student has reached a desired level of proficiency. The chart method is amenable to simulation by computer, because it is a comparatively well-structured method of instruction. It has a fixed format, and the organization of the dialogue can be specified through a small number of exercise types, with simple branching logic.

Results

Course description. The purpose of the computer-assisted instruction course in pulmonary diseases is to improve the clinical acumen of the student, not to teach basic content. An important prerequisite to the course is that the student have a background knowledge of pulmonary disease. It is highly recommended that, when necessary, the student acquire this knowledge from various textbooks or primers in pulmonary disease (1–4).

After registering for the course, the student reads the first case history provided in a notebook available at the computer terminal. Each case history consists of present illness, past and family history, physical examination, and laboratory findings. Once he has studied the case history, the student is ready to interact with the computer. First, he must select the correct diagnosis, which he can choose from a list of 59 possible diagnoses in the notebook. On selection of the correct diagnosis, the student must defend his choice. The entire case history is divided into multiple reasons for diagnosis, which are consecutively numbered. In selecting reasons, the student need only enter a 1- or 2-digit number. The computer responds to each selection by providing teaching information that reinforces an appropriate selection, and rebuts an inappropriate one. The student must list at least 75 per cent of the appropriate reasons that support his diagnosis. After these are given, the student may proceed to the management section.

The student selects the appropriate management from a list of 57 such components provided in the notebook. The management section is sequential, and the student is confronted with changing problems. An appropriate management at one stage in the course of the illness may become inappropriate at another stage.

The list of possible diagnoses is shown in figure 1. An example of student-computer interaction in diagnosis and defense of diagnosis is shown in figure 2A; figure 2B is an example of student-computer interaction in management of the patient studied.

This course consists of 10 case histories that represent 10 commonly encountered pulmonary diseases.

Scoring. Each reason given in defense of the diagnosis is scored in one of the following ways: (*1*) appropriate, (*2*) useful, but not essential to differential diagnosis, (*3*) inappropriate. After successful defense of the diagnosis and also after completion of the management section, the computer types out a summary evaluation of the student's choices.

A major incentive for using this computer-assisted instruction course was its time-saving aspect. Because time is valuable to the practicing physician, the writers used time as a motivator. A student knowledgeable in the pulmonary field who applied his knowledge could complete one case history in approximately 15 minutes;

Respiratory Disease

DIAGNOSES

I.
1. Congenital abnormalities

II. Lung Infections
2. Viral pneumonia

Bacterial pneumonia:
3. —Diplococcal pneumonia
4. —Staphylococcal pneumonia
5. —Klebsiella pneumonia
6. —Hemophilus pneumonia

7. Mycoplasma pneumonia
8. Rickettsial pneumonia

Fungal pneumonia:
9. —Histoplasmotic pneumonia
10. —Coccidiomycotic pneumonia
11. —Blastomycotic pneumonia

Mycobacterioses:
12. —typical
13. —atypical

14. Lung abscess
15. Bronchiectasis

III. Pneumoconioses
16. Silicosis
17. Asbestosis
18. Beryllosis

IV. Diffuse Interstitial Fibroses:
19. —Drug induced
20. —Associated with collagen diseases
21. —Idiopathic

V.
22. Sarcoidosis

VI. Chronic Obstructive Pulmonary Disease
23. Bronchial asthma
24. Chronic asthmatic bronchitis
25. Chronic bronchitis
26. Centrilobular emphysema
27. Panlobular emphysema

VII. Pulmonary Circulatory Disease
28. Pulmonary embolism
29. Heroin pulmonary edema
30. Primary pulmonary hypertension

VIII. Neoplasms of Lung

Benign:
31. —Adenoma

Malignant:
32. —Bronchogenic carcinoma
33. —Adenocarcinoma
34. —Alveolar cell carcinoma
35. —Lymphoma
36. —Metastatic carcinoma from outside lung

IX.
37. Idiopathic pneumothorax

X.
38. Foreign body obstruction

XI. Miscellaneous
39. Reaction to organic dusts
40. Reaction to fumes and gases
41. Radiation pneumonia
42. Lipoid pneumonia

Necrotizing angiitis:
43. —Polyarteritis nodosa
44. —Wegener's granulomatosis
45. —Goodpasture's syndrome

46. Histiocytosis X
47. Pulmonary alveolar proteinosis
48. Pulmonary alveolar microlithiasis
49. Idiopathic pulmonary hemosiderosis
50. Acquired cystic lung disease
51. Kyphoscoliotic lung disease
52. Hyaline membrane disease in infant — Acute respiratory distress syndrome in infant
53. Shock lung (respirator lung) — Acute respiratory distress syndrome in infant
54. Primary alveolar hypoventilation
55. Unilateral hyperlucent lung (Swyer-James or McLeod syndrome)

Primary pleural disease:
56. —Mesothelioma

Primary mediastinal disease:
57. —Idiopathic mediastinal fibrosis
58. —Mediastinal emphysema

59. Cystic fibrosis

Fig. 1. List of possible diagnoses.

however, if he made many errors. It might take as long as 2 hours, particularly if he selected an incorrect diagnosis, inappropriate defense of the correct diagnosis, or inappropriate management.

Data collection and evaluation. Evaluation of the CAI course as a tool for medical education has been a primary interest of the team. An evaluation design was sought to provide not only information concerning the individual student, but also to allow an objective appraisal of CAI as a tool for improving clinical decision-making among practicing physicians.

The evaluators played a major role in the course preparation. Their major contributions were in the following areas: design of the course, design of data collection format, design of printouts, construction of instruments for teaching, design of appropriate measures of achievement, and interpretation of results.

The scoring procedure is supplemented by a system for retrieval of data. Data that can be collected include: list of diagnoses selected, reasons selected and their frequency, list of forms of management used as well as their order of selection, number of times inappropriate management selected, and time taken to complete the

Diagnosis and Treatment
of Respiratory Diseases
Case 1

CAI: After reading each case history you will be asked to choose a diagnosis and select those features in the case history which support this diagnosis.
At the end of each section your performance will be evaluated.
Enter to continue.

CAI: Have you read case history 1 P. 101?
Answer yes or no.
S: Yes

CAI: Turn to page 6 which contains a list of possible diagnoses.

CAI: What is your working diagnosis?
S: 24

CAI: 24
This is the diagnosis you have given.
Is it the one you wish to defend?
Answer yes or no.
S: Yes

CAI: Incorrect.

CAI: What is your working diagnosis?
S: 23
CAI: 23
This is the diagnosis you have given.
Is it the one you wish to defend?
Answer yes or no.
S: Yes

CAI: List a reason for your diagnosis or type "End."
S: 1 [Age 17] *
CAI: Appropriate.
Most patients with bronchial asthma are less than 35 years old.

CAI: List a reason for your diagnosis or type "End."
S: 2 [White] *
CAI: Inappropriate.
There is not an increased predilection for bronchial asthma in caucasians.

CAI: List a reason for your diagnosis or type "End."
S: 4 [Wheezing, "tight chest" and dyspnea of 2 hours duration.] *
CAI: Appropriate.
These are signs of bronchospasm which is caused by hypersensitivity of the airways.

*This statement is in notebook, but not part of machine response.

Fig. 2A. Sample student-computer interaction, defense of diagnosis.

case history. A sample computer printout of the objective data related to the defense of the diagnosis is given in figure 3.

The course is at present being used to supplement daily, bedside teaching in the pulmonary disease elective offered to fourth-year students at the Downstate Medical Center. Approximately 50 students per year (one quarter of the senior class) are registered in the elective, and they are requested to take this course. Student reaction to the program is variable. Most believe that it is a distinct help to them in reinforcing principles expounded at the bedside. They find the computer simple to operate, and the teletypewriter printout is as fast or faster than they can read. Furthermore, they believe that the printout can be taken home and saved for future reference.

The major usefulness of this computer program to the writers has been as a teaching tool that reinforces bedside instruction. Few textbooks present case histories and extract from them a diagnosis, a defense of diagnosis, and a regimen of management. The instruction is individualized, so that the student receives an immediate response to whatever selections he has chosen.

The present report deals with the development of a CAI program in respiratory disease.

CAI: Turn to pages 7–9 which contain the list of managements.
Type "End" when you feel you have given all the appropriate managements.

CAI: Enter to continue.

CAI: How would you manage the patient in your office?
S: 1 [Nebulization. Process of administering fine particles of saline or alternately medicine, e.g., Isuprel, which can be dissolved in saline.] *

CAI: Appropriate.
Use of a freon aerosolized Isuprel nebulizer is indicated.
The pulmonary function tests have demonstrated the effectiveness of Isuprel in relieving the air trapping.

CAI: How would you manage the patient in your office?
S: 2 [Respirator — pressure cycled.] *

CAI: Inappropriate.
This form of management is not indicated at this point in this patient's disease.

CAI: How would you manage the patient in your office?
S: 6 [Nasal O_2 — 4 liters per minute.] *

CAI: Appropriate.
Hypoxemia is very commonly present during asthmatic attacks and correction is important.

CAI: How would you manage the patient in your office?
S: End

CAI: You have given sufficient managements that are appropriate at this time.
You have given the following responses.
7 appropriate management(s).
2 inappropriate management(s).

CAI: This disease is bronchial asthma. It is an inherited disease characterized by hyperreactivity of the bronchial musculature to a variety of stimuli which result in abnormal increases in airway resistance to otherwise normal levels of stimulation. The responsible stimulants include allergens, cold, irritants and infection, as well as emotional stimulation mediated through the vagus nerve. About 50% of asthmatics can raise or lower their airway resistance in response to suggestion.

The disease is very widespread, but in all probability most asthmatics do not become clinically overt. Those with clinical symptomatology usually have the disease appear in childhood or in early adult life. Only a distinct minority of patients have intractable recurrent asthmatic episodes. This group, especially in early adult life, have multiple precipitating causes for their attacks and emotional reactivity plays a major part in their disease while allergens do not.

The treatment of bronchial asthma is extremely difficult, and taxes the imagination and ingenuity of even the so-called "expert."

* This statement is in notebook, but not part of machine response.

2B. Sample student-computer interaction, management.

As soon as all preliminary data are collected on the program's content, a pre-test/post-test evaluation will be used for comparison purposes and for follow-up. These studies are now being planned. All established computer programs at the Downstate Medical Center have as basic requirements pre-test and post-test evaluations.

Discussion

Pulmonary diseases are commonly encountered in the practice of medicine. They involve a major class of patients who receive governmental disability pensions. They result in frequent employee absenteeism.

Most training programs for interns and residents emphasize the diagnosis and treatment of hospitalized patients. Training in management of the ambulatory patient is often deficient, because the house officer does not continue to follow his patient on the outside. When these physicians enter practice, they have had very little instruction in the outpatient management of disease. Their clinical decision-making is often on a "learn as you go" basis. Furthermore, postgraduate training programs and continuing education programs are basically designed to provide factual information.

The present course assumes the availability of other sources for basic knowledge of pulmonary disease. The chart method of teaching, a traditional method for reinforcing clinical competence, has been simulated in an attempt to improve the student's application of information to patient care. The evaluation program

COURSE RESPDT CASE NUMBER 1 STUDENT NUMBER 1

DIAGNOSIS NUMBER 15
CHOSEN TO DEFEND
DIAGNOSIS TYPE CORRECT
SUMMARY OF REASONS FOR DIAGNOSIS 15

RESPONSE TYPE	FREQUENCY	PERCENT FREQUENCY	CUMULATIVE FREQUENCY	PERCENT OF MAXIMUM	MEAN TIME	STANDARD DEVIATION OF TIME	LEAST TIME	MOST TIME	PERCENT TOTAL TIME	CUMULATIVE PERCENT TIME
APPROPRIATE	8	100.00	100.00	-99.99	212.38	0.89	212.	213.	100.00	100.00
INAPPROPRIATE	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00
REVIEW	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00
END	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00

TOTAL RESPONSE TIME 637. SECONDS
TOTAL RESPONSES 3
AVERAGE RESPONSE TIME 212. SECONDS

COURSE RESPDT CASE NUMBER 1 STUDENT NUMBER 1

SUMMARY DATA FOR DIAGNOSIS

DIAGNOSIS TYPE	FREQUENCY	PERCENT FREQUENCY	CUMULATIVE PERCENT FREQUENCY
CORRECT	1	0.25	0.25
DEFENSIBLE	1	0.25	0.50
NON-DEFENSIBLE	1	0.25	0.75
NOT OFFERED	1	0.25	1.00

TOTAL DIAGNOSES GIVEN 4

ORDER OF DIAGNOSES GIVEN

NUMBER	TYPE
14	DEFENSIBLE
13	NON-DEFENSIBLE
12	NOT OFFERED
15	CORRECT

COURSE RESPDT CASE NUMBER 1 STUDENT NUMBER 1

SUMMARY OF RESPONSES FOR STUDENT NUMBER 1
CASE 1

RESPONSE TYPE	FREQUENCY	PERCENT FREQUENCY	CUMULATIVE FREQUENCY	PERCENT OF MAXIMUM	MEAN TIME	STANDARD DEVIATION OF TIME	LEAST TIME	MOST TIME	PERCENT TOTAL TIME	CUMULATIVE PERCENT TIME
APPROPRIATE	3	100.00	100.00	-99.99	212.33	0.58	212.	213.	100.00	100.00
INAPPROPRIATE	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00
REVIEW	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00
END	0	0.0	100.00	-99.99	0.0	0.0	0.	0.	0.0	100.00

TOTAL RESPONSE TIME 637. SECONDS
TOTAL RESPONSES 3
AVERAGE RESPONSE TIME 212. SECONDS

Fig. 3. Sample computer printout of the objective data related to the defense of the diagnosis.

makes it possible to provide feedback information concerning the student's performance, both as an absolute and in relation to comparison groups. Areas of strength and weakness can be indicated.

The programming format used for this course has provided an implemented and easily exportable, computer-assisted instructional system for the development of further courses. The adaptability of this format to other subject areas has been demonstrated by the preparation of two new courses in rheumatic diseases and gynecologic oncology.

The lack of any objective system for measuring the ability of this course to result in improved delivery of care is a weakness of the present project. Potentially, the course evaluation system itself could be applied to assess the clinical competence of the physician-student. One of our present goals is the design of techniques to make this possible.

Extensive use of CAI as discussed in the present paper should provide an implemented and easily exportable system for the development of many courses in clinical decision-making in medicine, and a system for the evaluation of the effects of this type of continuing medical education on a physician's performance in his practice. The CAI as a vehicle of instruction and means of simulating the case study technique has a great potential to accomplish this in a most effective and economic way. Its use may result in qualitative improvements in instruction, more efficient use of instructional staff, and major savings in instructional time. Its potential widespread availability would provide a cost-effective way to reach and train a larger number of doctors in clinical decision-making than is possible with existing techniques.

The ultimate question is whether the learning benefits of CAI are superior to those of other methods. At present, there is no definitive answer to this question; however, our experience with programs in rheumatic diseases and in gynecologic oncology reveal that, at the very least, there is as much cognitive learning by means of a CAI program as by other more traditional modalities. The writers believe that CAI programs are a more efficient means of learning for students of medicine, but only with the passage of time and further evaluation will comparison studies be able to document this belief. This report represents a first step in introducing a new modality (CAI) into the teaching of pulmonary medicine.

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